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RESEARCH PAPER

Projected benefit-cost analysis of agri-silvicultural system: vegetable crops intercropping with *Salix alba* (Willow)

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Abstract: An experiment upon an agri-silvicultural system involving Willow (*Salix alba*) tree, Kale (*Brassica oleracea* var. *acephala*) and Knol khol (*Brassica oleracea* var. *caularapa*) was laid in randomized block designed at farmers' willow field at Shalimar near Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar India during 2005 and 2006. The main plot was divided into sub-spots with 8 m × 2 m in size each in which four two-year-old willow (*Salix alba*) trees were at a spacing of 2 m × 2 m in a sub-spot. The intercrops were maintained at recommended spacing and supplied with recommended doses of fertilizers. The benefit-cost ratio in willow plantation intercropped with vegetable crops of Kale and Knol Khol was analyzed and compared with the benefit-cost ratio of sole willow tree forestry. The results showed that every rupee invested in plantation of agri-silvicultural system generates benefit-cost ratio of 2.78 and 2.79 in case of Willow intercropping with Kale and Willow with Knol khol, respectively, while as for sole crop of willows benefit-cost ratio was calculated to be 2.66. These results provided circumstantial evidence in favour of adopting agroforestry involving willow instead of Sole tree forestry.

Keywords: benefit-cost ratio; intercrops; *Salix alba* (Willow); vegetable crops

Introduction

The state of Jammu and Kashmir in the northern India comprises three distinct climatic regions viz; subtropical region of Jammu, temperate Kashmir Valley and cold desert area of Ladakh (Lawrence 1998). The cultivation of willow (*Salix* spp.) has a long history for its variety of benefits to mankind, which is grown in many areas of the world for bioenergy and bioproducts, agroforestry and phytoremediation (Volk et al. 2006; Bridgeman et al. 2008). *Salix alba* (Willow) commonly known as the white willow or English willow is an introduced willow species. It grows upon 2100 m above m.s.l. and has the character of a height of about 30 m and girth from 1 to 2 m. This tree species is most favored on account of its fast growth, multipurpose utility, high adaptability and short rotation, thereby ensuring quick returns to the farmers. Due to its short rotation, *Salix alba* is a great boost to the rural economy (Heaton et al. 1999). The wood of willow is used for making fruit boxes (Apples) in Kashmir Valley. The other local and international uses of *Salix alba* include construction material for wide array of items like sweat lodges, furniture, baskets, splint of match boxes, and agricultural implements, etc. (Volk et al. 2006; Gruenewald et al. 2007). It is also suitable for making paper pulp and charcoal (Adler et al. 2008). Tender twigs are lopped for fodder for goats and sheep. The willow trees are also very effective as windbreak strips for the agricultural crops (Foereid et al. 2002)

Farming or agriculture is the main source of livelihoods for the local people in Kashmir and general rural Asian population. Trees on farmlands or in forests form an integral part of farming system. Both farmlands and forests are important for sustaining human habitations by providing food for nutrition and timber for construction and firewood as a form of energy besides providing fodder, grass and bedding materials for livestock. Trees are also important for the protection of environment and conservation of biodiversity (Gilmour et al. 1991a; Grimble et al. 1994). Nonetheless the food, fuel and fodder requirements of continuously increasing human and livestock population have generated enormous pressure on forest and arable land, leading to depletion of natural resources thereby affecting natural and human environment (MPFS 1991). Thus there is a limited scope to increase the area under cultivation for making the increasing demand of food, fodder, timber and fuel wood. The net result of this phenomenon is enormous scarcity of firewood (77%), timber (55%), green fodder (77%) and dry fodder to the tune of 51% (Roy 1999)

Agroforestry is the only viable alternative, which is capable of meeting the present challenges of shortages. It is an integrated land use approach, including cultivation of woody perennials in association with annual crops and holds immense potential to ensure stability and sustainability in production and to provide

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ecological and economic security as compared to conventional system of mono-cropping. Although there were a number of studies on Himalayan agroforestry systems (Toky et al. 1989; Gilmour et al. 1991a; Gilmour et al. 1991b; Ralhan et al. 1991; Sundriyal et al. 1994; Thapa et al. 1995; Sharma et al. 1995; Semwal and Maikhuri 1996; Singh et al. 1997), little work has been conducted in this regard in the Kashmir Himalayan region (Mir 2007).

The present study was undertaken to analyze benefit-cost ratio in willow (*Salix alba*) plantation by growing vegetable crops of Kale (*Brassica oleracea* var. *acephala*) and Knol Khol (*Brassica oleracea* var. *caularapa*) with willow trees, compared benefit-cost ratio of sole willow tree forestry. These vegetables were chosen since they are the most consumed vegetables in the valley and can be grown in different seasons of the year.

Materials and methods

The experiment on an agri-silvicultural system involving Willow tree, Kale and Knol khol (as vegetable crops) was laid in randomized block design at farmers' willow field at Shalimar near Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar India (Fig. 1) during 2005 and 2006. The farmer had planted two-year-old trees of willow, which formed on the basis of our experiment. The main plot was divided into sub-spots with 8 m × 2 m in size each in which four willow (*Salix alba*) trees were at a spacing of 2 m × 2 m in a sub-spot. The purpose of dividing main plot into sub-plots was for convenience of various cultural operations like weeding, hoeing, harvesting of vegetable crops, etc.. The experiment was replicated 5 times. The intercrops of Kale and Knol khol were maintained at recommended spacing and supplied with recommended doses of fertilizers.

Fig. 1 Location of the research trial field on agri-silvicultural system conducted at SKUAST-K, Shalimar Srinagar in Kashmir, India

Benefit-cost ratio of sole cropping tree and blend cropping (Tree + crop) was calculated by dividing the net present benefits with net present costs. The net present worth, on the other hand, was calculated by subtracting net present benefits by net present costs.

$$B = N_1/N_2 \quad (1)$$

where, B is the benefit-cost ratio, N_1 the net present benefits, and N_2 is the net present costs.

$$W = N_1 - N_2 \quad (2)$$

where, W is the net present worth (NPW).

Benefit-cost ratio and net present worth (NPW) analysis were conducted on per hectare. The cost of the propagating material is given in Table 1. Inputs like fertilizers were given to the vegetable crops during the experimental period, per hectare with per the package and practices of these vegetable crops (Table 2). The current prices of fertilizers were considered for calculating the cost of fertilizers used over the experimental period. The present market prices of propagating material like vegetable seeds and two-year-old willow stumps were considered in this project in order to account the recommended quantity of vegetable seeds per hectare and the number of willow stumps required at a spacing of 2m × 2m in a hectare. The cost of labour during the period of experimentation and projected cost of the labour to the rotation of willow were calculated by considering the rates paid to locally available labours (Table 3). The cost of vegetables, tree fodder, fuel wood and timber for cricket bat clefts are as per the local market (Table 4).

Table 1. Propagating material cost

Variable	Quantity	Rate (Rs.)	Amount (Rs.)
Willow stumps	2500	10/willow stump	25000
Kale	2.5 kg	150/kg	375
Knol khol	1.5 kg	150/kg	225

Table 2. Fertilizer cost

Variable	Quantity (kg·ha^{-1})			Rate (Rs.)*			Total amount
	Urea	DAP	MOP	Urea	DAP	MOP	(Rs.)
Kale	174	132	96	1044	1650	576	3270
Knol khol	251	132	128	1506	1650	768	3924

Notes: *@ Rs. 600, 1250 and 600 for one quintal each of Urea, DAP and MOP, respectively.

Table 3. Labour cost

Variable	Amount (Rs.)* Year						
	1	2	3	4	5	6-15	16
Kale	20000	18000	18000	18000	--	--	--
Knol khol	20000	18000	18000	18000	--	--	--
Willow	11620	3500	7000	10500	14000	358320	5040

Note: *@Rs. 70/labour day.

It may be observed that the costs invested in the initial year worked out to be more, which was mainly on account of land preparation, pit digging, fencing, implements, etc. and in the

subsequent years the costs earned were more in terms of harvesting of vegetables and tree fodder, fuel wood. However the environmental and social benefits of trees were not incorporated in the benefit –cost ratio analysis.

Table 4. Prevailing market prices of agricultural products

Item	Price (Rs.)
Kale	5000/t
Knol khol	5000/t
Fuel wood	3000/t
Tree fodder	750/t
Timber (Cricket bat clefts)	100/cleft

Assumptions

Forest tree planting is a long gestation venture, where heavy costs are incurred in initial years and benefits are realized after many years. Therefore for calculating the costs and benefits of forest plantation, all factors have to be considered in advance and the mean calculation is carried out at the beginning of the project (Ahmad 1989; Akachuku 1985). In our experimental trial, projected benefit-cost ratio analysis and net present worth (NPW) analysis of intercropping and sole tree crop were conducted. Rotation of willow was taken as 16 years. It is assumed that the whole tree crop will be harvested and sold in the market after this time as per the local practice by the farmers. The guiding rate of return (interest given on total cost and total benefits) was assumed to be equal to 12 percent.

To distribute growth potential of the site, besides increasing the net yield of timber and obtaining earlier returns from the capital invested in a stand, the thinning was presumed to be practiced after 8, 10 and 12 years. The intercropping of Kale and Knol khol in the subsequent years was assumed on the basis of growth performance with reference to reduction in yield.

Valuation of benefits

The value of vegetables, tree leaf fodder and fuel wood was actually weighed and valuation was calculated to being prevailing in the market prices on per hectare basis. The other produce like small timber obtained from thinning and timber for cricket bat clefts and fodder in subsequent years was actually assumed and valuation was also calculated to being prevailed in the market prices.

1. Fuel wood: Since fuel wood is sold in village market, its valuation was presumed on the basis of market prices.

2. Tree leaf fodder: It was sold on the weight basis i.e. Rs. /t. The tree leaf fodder was valued on the basis of prevalent average market prices for the trees of specific size and age.

3. Timber: The trees left up to rotation age (after 16 years) were presumed to have been cut for timber and manufacturing cricket bat clefts and valued as per market prices.

4. Vegetables: During 2 years of experiment, the vegetables (Kale and Knol khol) were sold as per prevailing market prices and yield of these intercrops in subsequent years was assumed on the basis of growth performance in comparison with reduction in yield.

Results and discussion

The data on the projected benefit –cost ratio are observed that there is a substantial increase in economic returns by growing Kale and Knol khol in association with willow trees, compared with sole willow forestry (Tables 5-7). The net profit worth (NPW) of willow Kale is Rs. 877 471 per hectare, NPW of willow with Knol khol is Rs. 883 371 per hectare (Table 5, 6) and NPW of willows (Sole willow crop) is Rs. 720 363 per hectare (Table 7).

Table 5. Projected cost of plantation/cultivation and benefit cost analysis of *Salix alba* with Kale (*Brassica oleracea* var. acephala) (Rs. /ha)

Item	Years							
	1	2	3	4	5	6-15	16	Total
Depreciation on fixed cost (Rs 56000) @10% & land rental	23600	23040	22536	22082	21674	201537	19153	333622
Plantation & Harvesting costs (Tree)	38420	5300	8800	12300	15800	376320	156840	613780
Cultivation & harvesting costs (Kale)	24827	22727	22727	22727	--	--	--	93008
Interest*	5388	3273	3412	3592	2411	36183	10703	64926
Total cost	92235	54304	57475	60701	39885	614040	186696	1105336
Fuel wood & fodder	--	15000	30000	45000	60000	2669400	21600	2841000
Timber (Cricketbat clefts)	--	--	--	--	--	--	900000	900000
Kale	88450	70130	52065	31875	--	--	--	242520
Total benefits	88450	85130	82065	76875	60000	2669400	921600	3983520
Discounted costs @12% pa.	92235	48330	45405	43098	25128	206932	29871	490999
Discounted benefits@12% pa.	88450	75766	64831	54581	37800	899586	147456	1368470

Notes: Fixed cost includes costs of fencing, irrigation, repairs, implements, etc.; Plantation/cultivation cost includes costs of planting material, seed, fertilizer, labour costs, etc. and 5% miscellaneous charges. *Represents interest on fixed cost @ 6.75% and on variable cost @ 6%. Net Profit Worth (NPW) =Rs. 1368470 – Rs. 490999= Rs. 877471; benefit-cost ratio = Rs. 1368470/Rs. 490999 = 2.78.

Study on projected benefit –cost ratio analysis showed that agri-silvicultural system generated benefit –cost ratio of every rupee invested in plantation was 2.78 and 2.79 in case of willow with Kale and willow with Knol khol, respectively. While in case

of sole tree crop of willow, benefit –cost ratio was found to be 2.66. It may be noted from the Tables 5 and 6 that in the first year the cost of Rs. 88450 and Rs. 91835 per hectare was from Kale intercropping with willow and Knol Khol with willow, respectively. In case of sole Willow crop, there were no benefits at all for the first year. In the subsequent years, the shading effect of trees will decrease the yield of vegetable crops; still more revenue from vegetables was there, which resulted in the higher benefit –cost ratio in case of Willow intercropping with Kale and Willow with Knol Khol as compared to sole tree crop. This difference in benefit –cost ratio between Willow intercropping with Kale and Willow with Knol Khol was on account of higher yield of Knol Khol which gave higher prices. The present study supports the fact that there is an increase in the levels of farm income when the agroforestry system is adapted as supported by other workers in this field (Jain et al. 1999). Similar results were reported by Majumdar (1991) and Kareemulla et al. (2002), who reported higher gross and net returns from agri-silviculture system over sole crop system. Reddy and Korwar (1985) and Pathak (1991) also used benefit –cost ratio for evaluating the comparative economics of crops and silvopastoral systems under dry land conditions. The results of this study provided circumstantial evidence in favour of adopting agro-forestry over sole forestry.

Table 6. Projected cost of plantation/cultivation and benefit cost analysis of *Salix alba* with Knol khol (*Brassica oleracea* var. *caularapa*) (Rs./ha)

Particulars	Years							
	1	2	3	4	5	6-15	16	Total
Fixed costs & land rental	23600	23040	22536	22082	21674	201537	19153	333622
Plantation & Harvesting costs (Tree)	38420	5300	8800	12300	15800	376320	156840	613780
Cultivation & harvesting costs (Knol khol)	25356	23256	23256	23256	--	--	--	95124
Interest*	5419	3268	3444	3623	2411	36183	10703	65051
Total cost	92795	54864	58036	61261	39885	614040	186696	1107577
Fuel wood & fodder	--	15000	30000	45000	60000	2669400	21600	2841000
Timber (cricket bat clefts)	--	--	--	--	--	--	900000	900000
Knol khol	91835	73070	53140	33210	--	--	--	251255
Total benefits	91835	88070	83140	78210	60000	2669400	921600	3992255
Discounted costs @12% pa.	92795	48829	45848	42495	25128	206932	29871	492898
Discounted benefits @12% pa.	91835	78382	65681	55529	37800	899586	147456	1376269

Notes: Fixed cost includes costs of fencing, irrigation, repairs, implements etc.; Plantation/cultivation cost includes costs of planting material, seed, fertilizer, labour costs etc. and 5% miscellaneous charges. *Represents interest on fixed cost@ 6.75% and on variable cost @ 6%. Net Profit Worth (NPW) = Rs. 1376269 – Rs. 492898 = 883371; benefit-cost ratio = Rs. 1376269/Rs. 492898 = 2.79.

Table 7. Projected cost of plantation and benefit cost analysis of *Salix alba* stand (Rs./ha)

Particulars	Years							
	1	2	3	4	5	6-15	16	Total
Depreciation on fixed cost (56000) @ 10% & land rental	23600	23040	22536	22082	21674	201537	19153	333622
Plantation & Harvesting costs (Tree)	38420	5300	8800	12300	15800	376320	156840	613780
Interest*	3898	1873	2049	2228	2411	36183	10703	59345
Total cost	65918	30213	33385	36610	39885	614040	186696	1006747
Fuel wood & fodder	--	15000	30000	45000	60000	2669400	21600	2841000
Timber (Cricket bat clefts)	--	--	--	--	--	--	900000	900000
Total benefits	--	15000	30000	45000	60000	2669400	921600	3741000
Discounted costs@12% pa.	65918	26889	26374	25993	25128	206932	29871	433479
Discounted benefits@12% pa.	--	13350	23700	31950	37800	899586	147456	1153842

Notes: net profit worth (NPW) = Rs. 1153842 – Rs. 433479 = Rs. 720363; benefit-cost ratio = Rs. 1153842/Rs. 433479 = 2.66. Fixed cost includes costs of fencing, irrigation, repairs, implements, etc.; Plantation/cultivation cost includes costs of planting material, seed, fertilizer, labour costs, etc. and 5% miscellaneous charges. *Represents interest on fixed cost @ 6.75% and on variable cost @ 6%.

Conclusions

Growing of trees along with annual crops is a sound practice and holds a special promise at a time when land resources are shrinking. This practice has a potential of meeting the demand of fuel, fodder and food simultaneously. However due to the differences in growth behavior and resource requirement of trees and crops, interaction between the two is bound to occur. In Kashmir valley, farmers usually plant tree on marginal lands. It is demonstrated that annual crops like Kale and Knol Khol can also be grown in association with willow trees successfully.

The results of Kale (*Brassica oleracea* var. *acephala*) and Knol Khol (*Brassica oleracea* var. *caularapa*) intercropping with willow revealed that Knol khol intercropping with willow generated the highest return of 2.79 (in terms of benefit-cost ratio) and was closely followed by Kale (2.78). The benefit-cost ratio of sole crop willow trees was calculated for 2.66. This ratio of sole willow forestry, comparatively lesser than intercropping with above vegetables (Agroforestry system), provides circumstantial

evidence in favour of adopting agroforestry over sole forestry. Although the results are based on the experimentation at a single site at regional level, its scope can be immense at an international level.

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